SOME THINKING ABOUT 'SYSTEM'

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FRONTISPIECE

SYSTEM

1. An aggregation or assemblage of objects united by some form of regular interaction or interdependence; a group of diverse units so combined by nature or art as to form an integrated whole, function, operate, or move in unison and, often, in obedience to some form of control; an organic or organized whole; as, to view the universe as a system; the solar system, a new telegraph system.

Knotted systems of steep, small hills. Owen Wister.

2. Specif. (a) The universe; the entire known world; -- often qualified by this; as, to regard this system with wonder. (b) The body considered as a functional unit; as Malaria pervades this system. (c) Colloq. One's whole affective being, body, mind, or spirit; as, his insinuation finally got into my system.

3. An organized or methodically arranged set of ideas; a complete exhibition of essential principles or facts arranged in rational dependence or connection; as, to reduce the dogmas to a system; also, a complex of ideas, principles, doctrines, laws, etc., forming a coherent whole and recognized as the intellectual content of a particular philosophy, religion, form of government, or the like; as, the theological system of Augustine, the American System of government; hence, a particular philosophy, religion, etc.

Our little systems have their day. Tennyson.

4. Hence: (a) A hypothesis; a formulated theory. (b) Theory as opposed to practice. (c) A systematic exposition of a subject; a treatise. All now rare.

5. A formal scheme or method governing organization, arrangement, etc., of objects or material, or a mode of procedure; a definite or set plan of ordering, operating, or proceeding; a method of classification, codification, etc.; as, the Dewy decimal system of classifying books; the Berillon system of fingerprinting; the Belgium system of tunneling; according to the Linnaean system; seeking a system by which to win at roulette.

6. Regular method or order; formal arrangement; orderliness; as, to have system in one's business.

7. (Usually with the) the combination of a political machine with big financial or industrial interests for the purpose of corruptly influencing a government. U. S.

8. Biol. Those organs collectively which especially contribute toward the important and complex vital functions; as, the alimentary or nervous system.

9. Eng. Law. Method or design as shown by other acts of a dependent similar to that charged, evidence of which is admissible to rebut or negative a defense of accident, mistake, or ignorance, or to prove a course of conduct.

10. Geol. A division of rocks usually larger than a series and smaller than a group, and deposited during a period; as, the Silurian system.

11. Gr. & Lat. Pros. A group of two or more periods. Also a group of verses in the same measure.

12. Music. (1) An interval regarded as a compound of two lesser ones; -- so used in Byzantine music. (2) A classified series of tones, as a mode or scale. (3) The collection of staffs which form a full score (which see).

13. Physcial Chem. An assemblage of substances in, or tending toward, equilibrium. Systems are classed as two component, or binary; three component, or ternary; etc.; also as univariant, bivariant, etc. (See Phase Rule).

14. Transportation. A large group of lines, usually of somewhat diverse character, under common ownership or permanent common control; as, the New York Central System.

15. Zool. In many compound ascidious, a group of zooids arranged about a cloacal cavity serving for them in common and into which the atrial orifices of all open.

Webster's New International Dictionary
Unabridged Second Edition

SOME THINKING ABOUT 'SYSTEM'

I. Introduction

Recently I experienced something that struck me as being quite strange. It was my good fortune to be able to attend an interdisciplinary meeting devoted to the study of and discussion on 'self-organizing systems.' The participants at the meeting represented a gamut of disciplines ranging from the physical and engineering sciences through the physiological and medical sciences to the psychological and sociological sciences. Eighteen people addressed the meeting and many others participated in subsequent discussions. Everyone of the people who spoke found it difficult, either explicitly or implicitly, to define 'system' in general and 'self-organizing system' in particular. In fact, one very senior and influential scientist in this area asserted that there is no such thing as a self-organizing system; then he asserted that he will continue to use the term, and did so.

Nevertheless, the meetings were quite successful as these things go. The papers were well thought out and, by and large, challenging. The animated discussion that followed them showed that they generated serious thinking on the part of many of the audience. This is paradoxical. For how can we speak intelligently, interestingly about something of which we cannot think clearly, which we cannot define?

Since then I have heard many people speak about problems concerning systems at various occasions. Forewarned, I was on the alert. It is a fact that many who speak about systems are uneasy with 'system'. They assert that they will not try to define it, that it is vague, ambiguous, fuzzy, and even meaningless. And yet, since both the speakers and the audience do have a concrete system in mind, the subsequent discourse using this

undefinable term proves often to be valuable and rewarding. 'System' is, of course, now defined as the concrete system under discussion. This permits the ensuing discussion to be fruitful, but it also has some undesirable side effects.

We cannot use words cavalierly, as Humpty-Dumpty recommends, without reaping some crop of confusion, be it in communication with others, or in communication with ourselves. All of us are aware of most, if not all, the definitions of 'system' given in the dictionary -- the definitions which are reproduced in the frontispiece to this paper. What's more, intuitively, willy-nilly, we accept all of them; after all, we have no alternative. The word is actually used in these ways in intelligent, meaningful discourse. Asserting that what we mean by 'system' is just a concrete concatenation of elements, the topic of the discussion, does not help us in the ensuing dilemma which makes every other definition of 'system' either wrong or meaningless. We cannot use words arbitrarily without, concomitantly, sapping the foundations of the organized, meaningful, stable world in which we live; in which we must necessarily perceive ourselves to live in order to function effectively. The all-too-oftenly heard apology that 'system' cannot be defined is a symptom of the disquiet, the ill-at-easeness that such a sapping generates.

Man cannot function too effectively when he is ill at ease; neither can he think too clearly. Ill-at-easeness generated by semantic confusion is generally unnecessary. This paper ~~will~~ attempt to dispell ~~at least~~ some of this confusion involving 'system'. It ~~will~~ attempt to show that 'system' is semantically legitimate per se, despite its many specific meanings by:

(a) reviewing some obvious but neglected facts of perception and cognition;

(b) explicating an implication of these facts -- the 'core meaning' of a word;

(c) trying to show that the many definitions of 'system' are correct applications of the core meaning of 'system' to concrete cases;

(d) formulating a possible taxonomy of these applications.

II. Some Obvious But Neglected Facts of Perception and Cognition

To say that something is obvious often serves as a kiss of death so far as further consideration of that something is concerned. But the obvious is often anything but simple. And in attempting to unravel the complexities that underlie the obvious, insights may be reached so something else which appeared to be complex and subtle thereby becomes simple and obvious. The obvious upon which I wish to focus attention is the nature of a thing, the nature of a stimulus, the nature of an idea. In what follows I will restrict myself to vision, but the points to be made are relevant to perception in general and are independent of the specific sensory modality mediating the perception.

In vision the lens in the eye focuses a projected picture of the environment upon the retina. The retina itself is basically a two-dimensional plane of points, each point being a light sensitive terminus of an individual neuron. Hence, in the visual perceptual process, there is a stage where the non-homogeneous pattern of light rays which 'carry' the picture of the environment is transformed to a non-homogeneous stimulation of a set of points that constitute the retina. As a result of this stimulation, each neuron that has a terminal point in the retina undergoes an electro-chemical change which

starts a process that goes 'upward' into the central nervous system. As an end result of the process, the person sees the environment.

Somehow, and at the present mysteriously, the organism manages to partition this set of discrete point stimulations into two sets, one set becoming the visual figure being looked at and attended to, the other set becoming the background to the figure. The figure looked at is experienced as being 'a thing'; whereas, the background is just sort of there, and may consist of 'nothingness' or some combination of 'nothingness' and things unattended to.

The problems entailed in how the nervous system functions for man to see a figure are well known to psychologists and physiologists, and much work is current in a quest for solutions. There is, in addition, a closely related problem which is not attended to -- the ability of man to see many different things in the environment confronting him. In other words, man can and does partition the set of discrete point stimulations relatively freely. This enables him to see that the figure has discriminable parts or that the background has discriminable parts. Even more important, this ability enables him to shift from one figure to another figure without a change in the visual field. Man, therefore, has the ability to organize the punctiform neural stimulation pattern and reorganize it. And this is important, both the organization and the reorganization are to a great extent a function of what is of interest to a person at the time of perception, of what is relevant to him.

The world appears to us to be as it is because we have a sensorium that responds to certain physical stimuli and a central nervous system that can process these responses and organize them in determinate ways. It so happens, and not by chance, that these ways are biologically relevant and this

facilitates man's existence on the earth. The above analysis may point to a solution of a vexing metaphysical problem which plagues and has plagued many philosophers as to what things really are. The 'fundamental' things which populate the world we live in are those aspects of the world which can generate punctiform stimulation patterns upon our sensorium which are organizable into visual figures.

Since the same visual field can be organized and reorganized in various ways depending upon vagaries within the perceiver, it seems proper to speak about <u>modes of visual organization</u>.

Something similar seems to hold for cognition, by cognition I mean what is generally denoted by 'thinking.' The information stored in the "memory banks" of a person's brain is analagous to the punctiform stimulus pattern impinging upon the peripheral sense organs. The idea we think about or the thought we are considering is analagous to the visual figure.

In olden days people liked to think that for each idea there corresponds a physical-thing-like engram which is sort of plucked out into consciousness when needed. Even slight consideration in a restricted mode of thinking, the use of words, shows that this is not feasible. Consider a person speaking or writing. Meaningful sentences emerge full blown. These sentences are combinations of words. Many of these sentences are unique in that they have never been used before. A sentence, by definition, expresses an idea. Yet the sentence per se could not have existed as an engram as such before its formulation. Words, of course, do and did exist; in this example, words are analagous to the punctiform stimuli. The sentence which expresses the idea is an organization of words. And this organization is determined by what is of interest to the person at the time of expression, of what is relevant to him.

It is difficult for me to grasp how an idea expressible by a sentence can exist as a determinate engram while the sentence expressing it must be organized from the unit words in the person's 'memory banks' at the time of expression. It seems simpler, and probably more correct, to look upon the process of organizing the words as one aspect of the basic underlying process of organizing the idea to be expressed. It is possible to bring additional arguments to buttress the contention that cognition exhibits rules of figure-ground organization and shifting figure-ground relationships similar to those found in perception, but I feel the above example to be sufficient.* Hence, consistent with the perceptual analog, it seems proper to speak about <u>modes of cognitive organization</u>.

Perceptual figure-ground organization and its shifting relationships seemed to point to a clarification of the metaphysical problem of what a thing is; conceptual figure-ground organization and its shifting relationships seems to point to a clarification as to what creativity is. Given a set of punctiform elements of some sort dwelling somewhere in the brain it is relatively easy to conceive of creativity as being a novel organization of a subset of these elements which, in turn, may lead to the creation of a new element. It is much more difficult to conceive of creativity as the emergence of a new engram from, from. . .from where?

*'Figure-ground organization' and 'shifting figure-ground relationships' are technical names for the two perceptual phenomena discussed above: 1.) The ability of the organism to segregate the punctiform stimulus manifold on the retina into a visual figure and a background, and 2.) The organism's ability to segregate the manifold into various different figures and backgrounds depending upon, among other things, its interests.

III. On Words and Substantives in General and on 'System' in Particular

It is the vogue among some philosophers and scientists to assert that the spoken language is a poor conveyer of meaning, that words have fuzzy meanings, ambiguous meanings, and sometimes even self-contradictory meanings. For evidence in support of this assertion they can point to many instances where people use words in a fuzzy, ambiguous or self-contradictory way. At this the intelligent man-in-the-street will indignantly rise and 'frumiously' exclaim that in these instances people misuse words, and that words should not be blamed for their being misused. And he is right. One should not blame words for the unfortunate fact that some people cannot use them correctly.

But, as is often the case, the philosophers and scientists are right too. Common language is a poor conveyer of what they have postulated meaning ought to be. They have postulated that the world must consist of some given set of irreducible unit things and that all perceivable and conceivable phenomena must be a result of lawful combinations of these unit things. A rigorous language should then be of a nature such that a sentence constructed in that language which denotes a phenomenon should clearly indicate the unit things and the lawful combinations which go into generating that phenomenon.

It so happens that regardless of whether these postulates are correct or not, man does not go about seeing and thinking in such a manner. spoken language is a most subtle general instrument to express the things man does see and the ideas he does think about. It is a necessary truth that a word or a proper grouping of words expresses either a discriminable perceptual figure-ground organization or a discriminable conceptual figure-ground organization. This is what distinguishes words from gibberish. When

a person understands a word he either perceives or conceives the figure-ground organization it expresses. If he does not understand the word he cannot perceive or conceive of a figure-ground organization which it may express. If he misunderstands the word the figure-ground organization he thinks it expresses is different from that which the user thinks it expresses. It is literally inconceivable for a person to speak meaningfully, to make sense, unless he, and his audience, know the figure-ground organizations which his words express. Hence the paradox experienced by all when we agree that we cannot define 'x' and then proceed to use 'x' in our discussions. Every substantive term or word in any spoken language is a name for a discriminable figure or discriminable part of a figure -- the part, of course, can, with the proper shift in figure-ground relationships, become a figure in its own right.

Now, I have argued that figures are anything but the irreducible, unique, unit things that some philosophy seems to consider to be necessary. They are flexible and changing. However, though they admit to being perceived or conceived as having parts or being part of a more inclusive figure, they nevertheless maintain an unit irreducible quality about them as long as they are figures. Substantive words or terms denote this quality. Perceptual figures exhibit the phenomenon of constancy. By this is meant the simple fact that a figure is seen as such despite many noticeable changes in its relationship to the perceiver or conceiver. A white sheet is seen as white whether it be under bright sunlight or dim electric light. So a word maintains a constancy of meaning regardless of the many distinct and different contexts in which it can be meaningfully used. This constancy of meaning which exists throughout the many different contexts or different specific

meanings for which the word can be properly used I call the 'core meaning' of the word. When we read a dictionary carefully and critically we see that for words with many specific definitions a common core meaning can easily be identified which differentiates this group of definitions from another group found for another word. Of course, it is sometimes the case that the core meaning is overlaid and hidden by historical accretions and must be uncovered through etymological analysis.

It follows that 'system' has a core meaning, and that that core meaning expresses a perceptual or conceptual figure, a discriminable, distinguishable invariant that can be identified amidst a host of different conditions and circumstances. What is this figure? The difficulty people have in identifying the figure is that they have looked for it in the wrong place; they have looked for it in the objective world, somehow equating the figure expressed by 'system' to be of the same nature as the figure expressed by 'dog', for example. Just as people could easily see the figural invariance of that thing called 'dog', they expected to find a similar invariance, 'out there' for that thing called 'system'. But the figure expressed by 'system' is not simply 'out there' -- obviously, otherwise there would be no trouble in defining it.

Earlier the terms 'modes of perceptual organization' and 'modes of cognitive organization' were introduced. The use of 'modes' implies that there is more than one mode of cognition and more than one mode of perception. It is my contention that a thing is called a system to identify the unique mode by means of which it is seen. We call a thing a system when we wish to express the fact that the thing is perceived as consisting of a set of elements, of parts, that are interconnected with each other by a discriminable,

distinguishable principle. Every one of fifteen definitions of 'system' in the frontispiece is a concrete exemplification of this core meaning.

Whenever one person can point to or explain a set of elements and the nature of the connectivity between these elements to another person, then the other person will perceive/conceive of the set as an entity, a thing. The word 'system' will then spontaneously emerge as the adequate expression, as the proper name for this thing. A system is therefore an interaction between what is 'out there' and how we organize it 'in here'. 'System' denotes an interaction between the objective world and how it is looked at or thought about; it denotes a mode of perceptuo/cognito organization.

'System' is a name for a very general invariance that can admit to very much variation in details. This does not make it fuzzy or ambiguous. 'A solar system' is just as clear and unambiguous as 'our solar system' although the latter case permits knowledge of many details that are in principle unknowable for the former. A general concept, no matter how clear and precisely formulated, tells us little about specific cases or sets of cases that are instances of this concept. 'A solar system' can tell us nothing about the specific number of planets, moons, comets, and their respective orbits, that will be found when we become able to see more clearly what goes on around other stars. 'A solar system' does however specify minimum conditions that an aggregate of astronomical entities will have to meet in order to be named 'solar system'. Within the bounds of these conditions there is room for infinite variety.

The mode of perceptuo/cognito functioning which enables us to perceive/cognize systems itself admits to various and different types of more concrete

exemplification. There are many different kinds of connectivity which enables man to group entities together to form a system. Hence the fifteen definitions to be found in the dictionary. A step in an attempt to classify and order different types and aspects of connectivity between entities will be made in the remainder of this paper.

IV. A Classification Into Bipolar Types That Are Somewhat Similar to Dimensions -- A Possible Taxonomy

1. Structural-functional -- static-dynamic

Phenomena can be seen or thought about in two ways. We can attend to those aspects of phenomena which do not change within a defined and delimited time span, and those that do. When the former serve as the perceptuo-cognito figure we speak of structure or of a static stage; when the latter are attended to we speak of function or of a dynamic state. What emerges as a structural figure and what emerges as a functional figure is determined by the time span under attention. If we consider an infinite time span nothing can be structure, as Heraclitus recognized long ago; everything changes in the fullness of time. On the other hand change disappears when we consider an infinitesimal instant of time since change makes no sense except as a specified relationship between at least two distinct instances in time.

The principle underlying the connectivity of a system during a given time period is static if the connection between the entities comprising the system can be seen or understood from knowledge of the state of the system for any one instant within that time period. If at least two instances within the time period are necessary before the principle can be demonstrated, the principle is then dynamic.

Shifting figure-ground relationships apply to systems as to any other kind of figures, hence the same set of entities can be looked at both from a static and a dynamic standpoint during the same time period. For example: the set of space-time points which constitutes a sleeping person during the wee hours of a night can be considered statically--a living organism which is inactive because it is asleep or it can be considered dynamically--a physiological organism undergoing an anabolism for which sleep is a necessity.

2. Purposive or non-purposive

So much nonsense has been written about purpose that scientists in general and social scientists in particular have had to, in some sort of self-defense, proscribe the use of the word in scientific discourse. With this, unfortunately, they threw the baby out with the bath, since purposiveness seems to be an essential characteristic of life. By refusing to face 'purpose' the study of life in general, and the study of systems involving life -- both physiological and ecological -- has become much more difficult.

Like every other meaningful word 'purpose' is a name for a discrimanable perceptuo/cognito figure. It denotes a distinguishable pattern of action. What characterises this pattern is convergence to a terminal state which is called 'its goal'. This convergence seems to be, to a considerable degree, independent of the vicissitudes of the external environment. It is this independence which enables us to assert that living organisms often exhibit great tenacity in achieving their goals, despite the great difficulties the environment confronts them with. In addition, the goal is

independent, at least as far as we know, of a point of maximum entropy. Goal-directed action generally decreases entropy than the opposite.

The often strange and generally unpredictable shape that the branches of a tree take in a crowded forest is seen/thought-of as the tree's quest for sun. The often equally strange and unpredictable shape the tree's root system will take is seen/thought-of as the tree's quest for water. (Note the word 'quest' which can be used properly in this context -- look up its meaning in a dictionary.) The movement of billiard balls exhibits a pattern distinctively different from the movement of basketball players; the pattern of a rock flying through the air is distinctively different from the pattern of a bird. And finally, note how actors have to move in order to communicate to the audience that they are robots or zombies; the goal of the behavior not being the goal of the behaving organism, but the goal of some external power which has the organism in thrall.

Purposive behavior generally can take one of two forms; it can be directed either towards the environment, or towards the system itself. When behavior is directed towards the environment it can either modify the environment so as to create a desired state, or it can overcome difficulties interposed between it and its desired state, or it can seek detours to circumvent and by-pass these barriers. In all these cases the specific actions to be taken by the living organism are unpredictable unless one knows beforehand the vicissitudes with which the environment will confront it.

When a beaver builds a dam or a rabbit digs a burrow, we have instances where the environment is being modified. When a dog chews through his leash he is overcoming difficulties interposed between himself and his

goal, a state of free movement. When an animal seeks a path through a dense underbrush to reach a source of water which it senses to be on the other side, it is trying to circumvent barriers. It is easy to bring more complex examples of human behavior for all these types of action directed towards the environment but not necessary. These examples from animal life will suffice.

Action directed toward the system itself is omnipresent when a living organism is considered from a physiological standpoint. Cannon, who was the first to stress this aspect of living action, gave it the name of 'homeostasis'. Homeostasis is different from equilibrium. A point of equilibrium in a system is that point where, given the constraints internal and external to the system, entropy is at a maximum. The homeostatic level is anything, as far as we know, but a point of maximum entropy; in fact the organism is almost continuously taking action to decrease its entropy in order to maintain its homeostatic levels.

Physiologically, a living organism can be characterized by constant endeavor to maintain homeostatic balance. Instances of homeostasis are the sugar level of the blood, the body temperature, the water content of the body, the hormonic balance, etc. With some generalization of the term, it is also possible to apply it to ecological communities and cultural configurations, since both seem able to initiate action as soon as certain entities that are part of them assume magnitudes above and/or below prescribed levels.

A man's knowledge of his world grew, he found it possible to contrive purposive systems of growing complexity. These systems are characterizable by 1.) an input to the system, 2.) a processing of the input by the system, and 3.) a consequent output which consists of the input as modified by the

system. The output of the system is the desired goal which man wished to achieve. In contriving this system man, therefore, had a definite intention in mind. Man-contrived systems are production systems and hence are purposive.

3. Mechanistic-organismic

Since systems comprise a set of elements or entities, and the connection between elements or entities, it is possible to change, remove, or extirpate elements and/or the connections between elements within them. A system in which the remaining elements, and their connections, undergo no change at this removal or extirpation is perceived as being intrinsically different from a system where they do. In the former case I will call the system 'mechanical'; in the latter case I will call it 'organismic'.

Much of 19th century science shared the ideal that all phenomena is ultimately reducible to a mechanical system consisting of unit elements and a push-pull connectivity between them. With the formulation and development of concepts such as the space-time gravitational field, the sub-atomic electronic field, or chemical equilibrium, this idea has been found to be, most probably, wrong. Natural dynamic systems seem to be organismic. One must almost perforce go along with the conclusion reached by Whitehead that all natural dynamic physical phenomena are organismic. Whitehead, however, seeks a cosmological solution. The aim of this paper is far less ambitious. All that is sought for here is a clarification of how man perceives and thinks about what he calls 'system'.

Man sees many static systems. Geography abounds with them. Mountain systems, archipelagoes, are good examples. If we remove one mountain for fill or connect two islands by a bridge we in no way affect the remaining

elements of the system. Most purposive production systems contrived by man are mechanical. So when a machine in a production line breaks down or a part of a machine breaks down no change occurs in the other elements or among the relationships between them. When the broken part or the machine is replaced the system functions as before.

Not all static systems are mechanical. One cannot take a part of a soap bubble away nor a part of a suspension bridge. An electro-magnetic field can also be considered to be a static organic system.

One can also speak of a partially organic system such that the change, removal, or extirpation will affect a proper sub-set of the system. Damming a tributary to a major river will affect the tributary and the main river below the point of confluence. It will not affect the water flow in the other tributaries or in the main river above the point of confluence.

4. The emerging taxonomy

The three bi-polar 'dimensions' just discussed generate eight cells:

1. Structural, Purposive, Mechanical,
2. Structural, Purposive, Organismic,
3. Structural, Non-purposive, Mechanical,
4. Structural, Non-purposive, Organismic,
5. Functional, Purposive, Mechanical,
6. Functional, Purposive, Organismic,
7. Functional, Non-purposive, Mechanical,
8. Functional, Non-purposive, Organismic.

By permitting oneself to indulge in some mental elasticity* one can find at least one perceivable/conceivable system to fit each of the cells. Here goes.

* Some, obviously unkind souls, would argue that 'elasticity' should be replaced by 'prestidigitation'.

A road network is easily a good example of a structural, purposive, mechanical system, cell 1. Road maps represent it adequately at a given instant in time, two instants being unnecessary; hence it is a structural system. It has an obvious purpose, that of connecting various communities and other desired geographical points to each other. It is mechanical because one can extirpate any part of it without introducing any change in the remaining parts.

As a structural, purposive, organismic system, cell 2, I will consider a suspension bridge. It is similar to a road network in the first two aspects, but no significant part can be taken from it without disturbing the forces acting upon every part of it. Hence it is an organismic system.

Many examples abound for a structural, non-purposive, mechanical system, cell 3. Let us look at a mountain range. We consider mountain ranges to be systems. They have no purposes, they are just there. If one levels any mountain in the system no conceivable change occurs in the rest of the system within time spans commensurate with a human life span.

Any physical system characterized as being in a static equilibrium can serve as an example for a structural, non-purposive, organismic system, cell 4. Consider an electromagnetic field, or better yet, consider a bubble. Both of these examples can be determined by knowledge of their state at one instant of time. They have no purpose; they just exist. And it is impossible to take any part out of them without changing the entire system, without changing the point of equilibrium.

Functional, purposive, mechanical systems, cell 5, abound around us. Men construct them all the time. A production line is a good example. It

makes no sense to think of it except as a temporal succession of steps within which raw material is processed and changed into a desired finished product. It is eminently purposive. If any machine in the line breaks down no change is undergone in any of the other machines in the line even though production may stop. Hence it is mechanical.

Living organisms, qua living organisms, are <u>the</u> examples of functional, purposive, organismic systems, cell 6. First, what is the meaning of a living organism at an instant in time, in contradistinction to static, structural anatomy? Unless we know its behavior, both internal and external we do not know it. Behavior is a time bound process; it is functional. Second, because I have no desire to get into metaphysical arguments as to what is really real and what is really scientific, I will assert dogmatically that the most parsimonious way to understand life at all its levels, from evolution, through physiological functioning, through overt behavior, to cultural and ecological configurations, is by means of purpose. Let us not confuse the mechanisms by which this purpose is achieved and the purpose itself. Perhaps, in some future, purpose can be eliminated and shown to be some sensible function of physical causality. At present this is far from being the case and the stubborn phenomenal facts do show purpose. Third, and finally, an organism is an organism.

Mental elasticity is needed to find an example for cell 7, a functional, non-purposive, mechanical system. Consider the flowing water in a river stream. It is functional since 'flowing' makes no sense unless one takes at least two instances of time into account. Now consider the wild Missouri in its untamed state or that river of tears, the Whang Ho. Both these rivers

exhibit a tendency to markedly change their channels occasionally. These changes have been local as compared to the total system, and they have had no effect upon the rest of the system. And rivers, per se, have no purpose. Hence the changing flow of water as a result of a change in the river bed can be considered to be an example of a functional, non-purposive, mechanical system.

The last cell, cell 8, a functional non-purposive, organismic system will become increasingly important if the physical sciences continue in the direction they have assumed since the formulation of Maxwell's field equations. More and more of the explanations given by the physical sciences to the observable facts of physical behavior are of the nature of a dynamic interdependent field. The atom and the circular four dimensional space-time continuum are both examples of such a system.

It is interesting to see how the fifteen definitions given in the dictionary fare with this taxonomy. Let us review them one by one.

Definition 1 is similar to the definition of 'system' as given in this paper. But this is hidden, implicit. It is also more limited than the definition presented here since it specifies only two of the six poles identified in this paper: organismic interdependence and function. It mentions four examples. The first two, the universe and the solar system clearly belong to cell 8. The next example, a telegraph system, is contextually, an example of cell 5. We can however, consider it from a structural standpoint exclusively, and then it belongs to cell 1. The last example, a quote from literature, a system of hills is clearly equivalent to my example for cell 1, a mountain range.

Definition 2 includes the universe again, which we have already treated. It also includes the body from a functional physiological standpoint, and from a psychological standpoint. Both of these fit into cell 6.

Definitions 3 and 4 both deal with the same class of things, systems of ideas connected to each other by some rational or coherent principle. These systems are structural and mechanical, and (somewhat elastically) I believe they are non-purposive, though, of course, the person who constructed them did have a purpose in mind. Hence they are examples of cell 3.

Definitions 5 and 6 deal with verbal instructions or formalized modes of procedures. They are structural, purposive -- they exist in order to instruct a person what to do, and they are mechanical. Hence they belong in cell 3.

Definition 7 concerns 'the system'. It is colloquial American and concerns the interests and powers which control the government to a greater and lesser extent. This system seems to be functional, since 'control' is time bound, purposive, and mechanical; a denizen of cell 5.

Definition 8 is about physiological subsystems that contribute toward vital physiological functions of the organisms. It obviously belongs to cell 6.

Definition 9 is a very interesting usage of the word. It names a body of evidence submissible to a court which points to the intention of the defendent. Since 'pointing to' is one of the perceptuo/conceptuo criteria for purpose, this system is purposive. Since it exists at a given instant in time it is structural. It is also organismic and interdependent, as it is the <u>totality</u> of the evidence which points; its meaning can change with the exclusion of any specific bit of evidence. Hence it belongs to cell 2, the only definition that fits into this cell.

Definition 10 is about a division of rocks in geology. Such a division is structural. It just happens to be there and has no purpose. In addition, it is mechanical. Obviously a candidate for cell 3.

Definition 11 concerns an identified poetic form, structure. It is structural, non-purposive, mechanical and belongs to cell 3.

Definition 12 concerns the way 'system' is used in music and is condeptually very similar to definition 11. However, since music is time bound, musical systems are functional. It is therefore a member of cell 7. The only definition to fit that cell.

Definition 13 concerns chemical systems in dynamic equilibrium. These have already been discussed as members of cell 8.

Definition 14 concerns a transportation system. It is discussed from a static standpoint, e.g., a large group of lines under common ownership. Since it is also purposive and mechanical it belongs to cell 1.

Definition 15 deals with physiological systems from a static, anatomical standpoint. As such it becomes static, non-purposive, and mechanical and belongs to cell 3.

Every one of the definitions seems to fit, without too much conceptual violence, into one of the cells. It is very interesting to note that not one of the systems defined in the dictionary fits into cell 5, a functional, purposive, mechanical system for which the example given was a production line. Other usages of 'system' that are common nowadays, like man-machine system, command-control system, and weapons system also seem basically to belong to this cell. The eight cells were generated through a systematic analysis of what the meaning of 'system' must be to make sense. Dictionary meanings are obtained through a thorough and assiduous 'nose counting'. The fact that

some of the best lexicographers in the country missed the specific meaning of 'system' in cell 5 seems to point, at least to me, to the superiority of even a simple intelligent analysis over the most elaborate and careful 'nose counting' and classification of what was counted.

In addition, it is interesting to note the example of the use of 'system' quoted from Owen Wister: Knotted systems of steep small hills. This usage does not conform to the general definition given just above it. Hills do not interact nor are they interdependent. They do not form an integrated, organic, or organized whole. Nor do they function, operate, or move in unison. They are grouped together and perceived as a system on the basis of similarity and proximity. But the general definition cannot handle this. The systematic analysis can and does.

V. Some Other Ways of Thinking About Systems -- Not Dimensions

1. Self-organizing systems

The term 'self-organizing systems' is basically an instance of verbal magic that accompanies the changing of a name. In many primitive societies a person has a 'real' name by which he is never called, and a 'false' name which all members of the society use to call him. This magic was considered to be effective in protecting the person from the evil spirits which abounded. If the evil spirit never heard the 'real' name of the person he could not know it; and if the spirit did not know the real name, he could not identify the person to harm him. In Victorian England the changing of the name of an object from 'leg' to 'limb' was believed to reduce the salaciousness of that object In our contemporary society 'passing away' is considered to be

less tragic than 'dying'; being called a 'mortician' seems to be considered more ennobling than being called an 'undertaker'.

Horrible dictu, and not too surprising since scientists are also human, this form of verbal magic has also appeared in scientific thinking. Primitive psychological behaviorism asserted that man does not 'think', rather man has 'non-vocal laryngeal movements'. Now this would have been significant, had the early behaviorists been able to demonstrate that every time a person experienced himself to be thinking, one could find that his larynx moved non-vocally. But such non-vocal laryngeal movements have yet to be found. The behaviorists proscribed 'thinking' ex cathedra; 'thinking' like 'leg' was considered to be a dirty word. This because methodological positivism, which uncritically underlays so much of contemporary scientific thinking, asserts that only that which is physical is really real -- in the case of life the really real is physico-chemical, e.g., movements of the larynx. The fact that we perceive/cognize many discriminable life processes that are a) most parsimoniously explainable by the concept of purpose, and b) are just not reducible, at present, to physical processes, sticks like a bone in the throat of many. Like drowning men clutching at straws they clutch at any physical phenomenon, reify it, and give it a name. Then they replace the name of the living phenomenon by the new physicalistic, 'scientific' name. They thereby exorcise the dirty words from their language.

As a result of exigencies of World War II, a technological breakthrough occurred in the design of control systems; simple control mechanisms have been known for centuries. The new control systems could sense subtle changes in the environment and could, as a result, modify the functional purposive system which they were designed to control. These modifications generally

changed the function of the system in light of changes in the environment. This is where feedback came into the general vocabulary. Feedback was part of the electronic designers vocabulary in the years prior to the war and, as already mentioned, was known for a longer period of time. What was radical in the new development was that now, for the first time, man developed a physical system which could 'see' the external world and change its behavior in a manner appropriate to what was 'seen'. The analogy with life sprang forth immediately and was met with excitement and enthusiasm -- at last a way was found to base living phenomena upon a physical substratum. The control systems were supposed to be analagous to the brain, and the systems they controlled, to the body. The total system was then given a name which was immediately, explicitly and/or implicitly, applied to living organisms. Hooray, a straw!

In the ensuing enthusiasm the very serious deficiencies of the analogy were not attended to. I can list many but will concentrate upon only one, since that is all that is necessary. It is an uncomfortable fact that man sees objects that are far away from him, that he sees at a distance. The sensa of the control system cannot; they can react only to the stimuli impinging upon their sense organs. Now it is true that man cannot see at a distance unless there are physical stimuli impinging upon his sensorium too. These are called proximal stimuli. But what he actually sees has a very tenuous relationship to the proximal stimuli. The only thing a control system can react to however is the proximal stimulus distribution. Psychologists denote this ability to see 'through' the proximal stimulus to the distant object by the term 'vicarious mediation'. Control systems do not exhibit any ability to respond to mediation vicariously. Hence the analogy is not well taken.

The conceptual confusion accompanying 'self-organizing system' results from the fact that explicitly and/or implicitly the scientists in defining this term wish to include both a certain set of physical systems and living organisms. This cannot be done since the set they have in mind is only superficially similar to living organisms and, although they may resist recognizing this, they feel it in their guts. If we restrict ourselves to physical systems the term offers no difficulty. Most systems contrived by man function mechanically in a prescribed manner. To change their functioning the intervention of a human operator is generally needed. To the extent that we can construct control systems that can change the functioning of the system without human intervention, to that extent we have self-organizing systems. It's as simple as that.

2. Central and peripheral properties and/or elements of organismic systems

In the preceding section it was noted that the self-organizing physical system was superfically similar to a human organism. In other words the aspects in which it was similar to a living organism were not important aspects. The ability to react to physical stimuli is not, per se, an important aspect of living/functioning; it is the ability to react to a distant object over a wide range of mediating stimuli which is important and which differentiates life, at least many advanced forms of life, from sensory machines. This points to a problem which can be generalized, a problem which does not seem to exist for mechanical systems. The problem can be crudely formulated as 'When is a man a man?' or 'When is a solar system a solar system?'.

Aristotle touched upon this problem when he asserted that a hand separated from a body is not a hand. I am not aware of him considering that a person without a hand is still a person. A hand, therefore, although it

itself has no meaning as such unless attached to a person, is peripheral to the person as far as him being a person is concerned. In fact we can subtract all kinds of things from a person without him ceasing to be a person. Wars generally contribute to human progress in many scientific fields. Medicine has learned much in the last war. One of the things it learned is how, more efficiently, to keep people alive despite all kind of fantastic external dismemberment which is never met with in peacetime. Hence we now have a small number of quadruple amputees living among us. They are still perceived as men. Limbs therefore are peripheral characteristics of human beings. Surprising? No! Monkeys have four human-like limbs.

On the other hand, idiots, neonates, or psychotics are generally not perceived as persons even though their bodies are intact. Rational consciousness and the behavior flowing from rational consciousness is a central property of man. We find something similar on a physiological level. The body can maintain relatively efficient life processes with many of its parts being subtracted from it. But there are other parts that are so essential to any ordered function that their slightest damage will cause death. Hence we have parts that are central for a physiological life and others which are peripheral. If we go to a solar system we find something similar but far simpler. In order for a solar system to be perceived/cognized there must be a sun and at least one planet circling it. All other possible aspects and properties of a solar system are peripheral.

The most general definition, the core meaning, of an organismic system must be restricted to its central properties. The inclusion of peripheral properties will almost always exclude certain instances of this organismic system which lack this peripheral property, but are still seen as being

the same as the defined system. This introduces confusion. A conceptual definition should be in accord with that which we see or think of spontaneously. I find it difficult to think through the problems entailed in how we perceive and discriminate centrality from peripherality in a systematic way. Nevertheless we do discriminate and if we disregard these discriminations we can often run into conceptual difficulties. One will learn very little about an organismic system if he focuses his attention on its peripheral aspects.

VI. Conclusion

The difficulty in defining 'system' in a specific context results from misusing a word which has a simple, clear meaning in a general context for a specific, concrete context. It is similar to the classical fallacy denoted by 'pars pro toto' or that which was called by Whitehead 'the fallacy of misplaced concreteness'. 'System' is at a level of generality similar to 'phylum'. If we know the phylum to which an organism belongs and nothing else we know very little about the organism. Ditto for system. The only things that need be common to all systems are identifiable entities and identifiable connections between them. In all other ways systems can vary unlimitedly. The quest for a more detailed, specified definition for 'system' is chimerical. The same holds for a quest for a general system analysis.

However, as I have attempted to show above, it is possible to group systems according to specifiable characteristics. The definitions for systems belonging to such groups become more detailed and specific. It is a fact that for many such groups, at present illy-defined, if defined at all, certain analytic

techniques are very appropriate. But it does not follow that they are appropriate for other groups of systems. By recognizing this we know better where we stand, the air gets clearer and we can see more clearly. And with this we can think better.